Claims

[c1] A method of forming a thermal barrier coating (26) on a surface of a component (10), the method comprising the step of forming the thermal barrier coating (26) of a thermal-insulating material of yttria-stabilized zirconia alloyed with at least a third oxide having an absolute percent ion size difference relative to a zirconium ion of at least 13 percent, the third oxide being present in the thermal-insulating material in an amount sufficient to increase lattice strain energy of grains of the thermal barrier coating (26), the thermal barrier coating (26) being formed to also contain elemental carbon, carbides, oxycarbides and/or a carbon-containing gas.

[c2] A method according to claim 1, wherein the third oxide is selected from the group consisting of ceria, magnesia, calcia, strontia, barium oxide, lanthana, neodymia, gadolinium oxide, dysprosia, ytterbia and tantala.

[c3] A method according to claim 2, wherein the thermal-insulating material is alloyed to contain an additional oxide selected from the group consisting of ceria, magnesia, calcia, strontia, barium oxide, lanthana, neodymia, gadolinium oxide, dysprosia, ytterbia and tantala.

[c4] A method according to claim 1, wherein the third oxide is ceria.

[c5] A method according to claim 4, wherein the thermal-insulating material contains about 10 to about 20 weight percent ceria, the balance essentially zirconia stabilized by about 4 to about 8 weight percent yttria. A method according to claim 4, wherein the thermal-insulating material contains about 10 to about 20 weight percent ceria, the balance essentially zirconia stabilized by about 4 to about 8 weight percent yttria.

[c6] A method according to claim 1, wherein the elemental carbon, carbides, oxycarbides and/or carbon-containing gas are within pores (32) that are within grains and at and between grain boundaries of the thermal-insulating material, the elemental carbon, carbides, oxycarbides and/or carbon-containing gas being present in the thermal barrier coating (26) in an amount sufficient to thermally stabilize the microstructure of the thermal-insulating material.

[c7] A method according to claim 1, wherein the forming step comprises evaporating at least one source material that contains carbon, a carbon-containing compound, and/or the thermal-insulating material.

[c8] A method according to claim 1, wherein the forming step comprises depositing the thermal barrier coating (26) by electron beam physical vapor deposition during which an ingot of the thermal-insulating material and a second ingot of a carbon-containing or carbide-containing material are evaporated.

[c9] A method according to claim 8, wherein the second ingot comprises graphite.

[c10] A method according to claim 1, wherein during the forming step a reaction occurs between the third oxide and the elemental carbon to form carbides and oxycarbides that increase the hardness of the TBC (26).

[c11] A method according to claim 1, further comprising the step of heating the thermal barrier coating (26) to cause a reaction between the third oxide and the elemental carbon that increases the hardness of the TBC (26).

[c12] A method according to claim 1, wherein the carbon-containing gas is at least one gas chosen from the group consisting of carbon monoxide and carbon dioxide.

[c13] A method according to claim 1, wherein at least some of the pores (32) contain elemental carbon.

[c14] A method according to claim 1, wherein at least some of the pores (32) entrap the carbon-containing gas.

[c15] A method according to claim 1, wherein the microstructure of the thermal barrier coating (26) consists of columnar grains (30) so that the microstructure is columnar, or flattened grains (30) so that the microstructure is noncolumnar and inhomogeneous.

[c16]

A method of forming a thermal barrier coating (26) on a surface of a superalloy component (10), the method comprising the steps of:
depositing a bond coat (24) on the component (10);

placing the component (10) in a coating chamber containing at least one source material comprising a thermal-insulating material and a carbon-containing and/or carbide-containing material, the thermal-insulating material consisting essentially of yttria-stabilized zirconia and ceria; and then
forming the thermal barrier coating (26) on the bond coat (24) at an elevated temperature by evaporating the at least one source material to co-deposit elemental carbon and the thermal-insulating material so that the thermal barrier coating (26) has a microstructure with pores (32) that are within grains and at and between grain boundaries of the thermal-insulating material, at least some of the pores (32) containing elemental carbon and/or carbides, oxycarbides and/or a carbon-containing gas that evolve from the carbon-containing or carbide-containing material at the elevated temperature.

[c17] A method according to claim 16, wherein the microstructure of the thermal barrier coating (26) consists of columnar grains (30) so that the microstructure is columnar.

[c18] A method according to claim 16, wherein the thermal-insulating material contains about 10 to about 20 weight percent ceria, the balance essentially zirconia stabilized by about 4 to about 8 yttria.

[c19] A method according to claim 16, wherein the forming step comprises depositing the thermal barrier coating (26) by electron beam physical vapor deposition, during which a reaction occurs between the ceria and the elemental carbon to form a ternary composition containing carbides and oxycarbides that increase the hardness of the TBC (26).

[c20] A method according to claim 16, further comprising the step of heating the thermal barrier coating (26) to cause a reaction between the ceria and the elemental carbon, forming a ternary composition containing carbides and oxycarbides that increase the hardness of the TBC (26).

[c21]

A thermal barrier coating (26) on a surface of a component (10), the thermal barrier coating (26) comprising a thermal-insulating material of yttria-stabilized zirconia alloyed with at least a third oxide having an absolute percent ion size

difference relative to a zirconium ion of at least 13 percent, the third oxide being present in the thermal-insulating material in an amount sufficient to increase lattice strain energy of grains of the thermal barrier coating (26), the thermal barrier coating (26) containing elemental carbon, carbides, oxycarbides and/or a carbon-containing gas.

[c22] A thermal barrier coating (26) according to claim 21, wherein the third oxide is selected from the group consisting of ceria, magnesia, calcia, strontia, barium oxide, lanthana, neodymia, gadolinium oxide, dysprosia, ytterbia and tantala.

[c23] A thermal barrier coating (26) according to claim 22, wherein the thermal-insulating material is alloyed with an additional oxide selected from the group consisting of ceria, magnesia, calcia, strontia, barium oxide, lanthana, neodymia, gadolinium oxide, dysprosia, ytterbia and tantala.

[c24] A thermal barrier coating (26) according to claim 21, wherein the third oxide is ceria.

[c25] A thermal barrier coating (26) according to claim 24, wherein the thermal-insulating material contains about 10 to about 20 weight percent ceria, the balance essentially zirconia stabilized by about 4 to about 8 yttria.

[c26] A thermal barrier coating (26) according to claim 21, wherein the elemental carbon, carbides, oxycarbides and/or carbon-containing gas are within pores (32) that are within grains and at and between grain boundaries of the thermal-insulating material.

[c27] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) contain elemental carbon.

[c28] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) entrap the carbon-containing gas.

[c29] A thermal barrier coating (26) according to claim 28, wherein the carbon-containing gas is at least one gas chosen from the group consisting of carbon monoxide and carbon dioxide.

[c30] A thermal barrier coating (26) according to claim 26, wherein at least some of the pores (32) contain the elemental carbon, at least some of the pores (32) contain carbides or oxycarbides, and at least some of the pores (32) entrap the carbon-containing gas.

[c31] A thermal barrier coating (26) according to claim 21, wherein the microstructure of the thermal barrier coating (26) consists of columnar grains (30) so that the microstructure is columnar, or flattened grains (30) so that the microstructure is noncolumnar and inhomogeneous.

[c32] A thermal barrier coating (26) on a surface of a superalloy component (10), the thermal barrier coating (26) comprising:a bond coat (24) on the component (10);a thermal-insulating material of yttria-stabilized zirconia alloyed with about 10 to about 20 weight percent ceria, the thermal insulating material having a columnar microstructure with pores (32) and sub-grain interfaces within, at and between grain boundaries of the microstructure, at least some of the pores (32) containing elemental carbon, carbides, oxycarbides, and/or a carbon-containing gas.

[c33] A thermal barrier coating (26) according to claim 32, wherein at least some of the pores (32) contain the elemental carbon, at least some of the pores (32) contain carbides or oxycarbides, and at least some of the pores (32) entrap the carbon-containing gas.

[c34] A thermal barrier coating (26) according to claim 32, wherein the thermal-insulating material comprises a ternary reaction product of ceria and the elemental carbon.

[c35] A thermal barrier coating (26) according to claim 34, wherein the ternary reaction product comprises carbides and/or oxycarbides.